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RDT&E PROJECT NO. 1D543312D46406

USATECOM PROJECT NO. 8-4-8300-04

YPG PROJECT NO. 3060

YPG REPORT NO. 6043

ENGINEERING/SERVICE DESERT ENVIRONMENTAL TEST OF FOXHOLE DIGGING AID (INTERIM)

SECOND FINAL REPORT

BY

WALTER E. SCHOUDEL, SP5
SCIENTIFIC AND ENGINEERING
NOVEMBER 1966

YUMA PROVING GROUND
YUMA, ARIZONA

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

25 JAN 1967

AMSTE-BC

SUBJECT: "Second" Final Report, Engineering and Service Desert Environmental Test of Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04, RDT&E Project 1D543312D46406

TO: Commanding General, U.S. Army Materiel Command, ATTN: AMCRD-DM
Commanding General, U.S. Army Combat Developments Command, ATTN: USACDC LnO, USATECOM

1. References:

a. Ltr, AMSTE-BC, HQ USATECOM, 3 Sep 1965, Subj: Final Report of Engineering Test of Foxhole Digging Aid, EL-4 (Interim) Report No. DPS-1752, August 1965, USATECOM Project No. 8-4-8300-01.

b. Ltr, AMSTE-BC, HQ USATECOM, 10 Jan 1966, Subj: Final Report of Service Test of Foxhole Digging Aid EL-4 (Interim), USATECOM Project No. 8-4-8300-02.

c. Ltr, AMSTE-BC, HQ USATECOM, 18 Mar 1966, Subj: Final Report of Engineering and Service Desert Environmental Test of Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04, YPG Report 5028.

d. Ltr, AMSTE-BC, HQ USATECOM, 26 Apr 1966, Subj: Letter Report for Engineering and Service Arctic Environmental Test of Foxhole Digging Aid (Interim), RDT&E Project No. 1D543312D46406, USATECOM Project No. 8-4-8300-03.

2. Subject report is approved by this headquarters. Copies are furnished for review and comment.

3. References 1a through 1d provide USATECOM position relative to the Foxhole Digging Aid at the completion of various phases of the testing program. In summary these include recommendations as follow:

a. The Foxhole Digging Aid EL-4 (Interim) be considered suitable for temperate zone U.S. Army use when the deficient instructions and as many of the shortcomings as practicable are corrected.

b. That efforts continue to develop a Foxhole Digging Aid that will be suitable for Arctic winter use.

25 JAN 1967

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SUBJECT: "Second" Final Report, Engineering and Service Desert Environmental Test of Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04, RDT&E Project 1D543312D46406

c. That additional Desert Environmental Testing be conducted to determine:

(1) Suitability of the test item to withstand normal normal-function air drop.

(2) Suitability of the plastic connection on the cratering charge.

(3) The ability of personnel to exert sufficient hand pressure on the activator button initiating the explosive.

(4) Suitability of the test item to perform in desert soils utilizing two, rather than one, foxhole digging aids.

4. The additional Desert Environmental Testing has been completed. Test findings, conclusions, and recommendations are contained in subject report. Major conclusions and recommendations are presented in succeeding paragraphs.

5. Conclusions:

a. The procedures prescribed for handling duds are a safe and effective means of disposing of duds under field conditions.

b. The Foxhole Digging Aid EL-4 is suitable for low velocity air drop, will withstand malfunction air drop and will not contaminate the drop zone after malfunction air drop when the item is rigged in a horizontal position.

c. The plastic connection on the cratering charge is suitable for use in the desert summer environment.

d. Personnel can exert sufficient hand pressure on the activator button initiating the explosive although this pressure (average 17 pounds) exceeds the requirement of the QMR.

e. Utilization of two foxhole digging aids is a suitable means for generating an excavation of acceptable dimensions in desert soils, although the user frequently experiences difficulty in emplacing the cratering charge.

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6. Discussion:

The recommendation, paragraph 1.6.d, page 4 of the report, is an inference not supported by test data. Before it can be accepted, further testing would be required with cratering charges of varied tapered configuration to provide valid evaluation of the extent to which tapering facilitates insertion in the pilot hole and any possible effect tapering may have on the size of the crater produced.

7. Recommendations: It is recommended:

a. That the Foxhole Digging Aid EL-4, when two are used, be considered suitable for desert use.

b. That in rigging for air drop, the Foxhole Digging Aid be placed in the package in such a way that it will be in a horizontal attitude during the drop.

c. That care be exercised when assembling a cratering charge which has been exposed to high temperatures for an extended period to prevent possible cracking of the plastic connector.

FOR THE COMMANDER:

Goodwin Morrow
GOODWIN MORROW
Astg Dir
Inf Mat Test Dir

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RDT&E PROJECT NO. 1D543312D46406

USATECOM PROJECT NO. 8-4-8300-04

YPG PROJECT NO. 3060

ENGINEERING/SERVICE DESERT ENVIRONMENTAL TEST OF FOXHOLE DIGGING AID (INTERIM)

TEST REPORT

BY

WALTER E. SCHOUDEL, SP5
SCIENTIFIC AND ENGINEERING
NOVEMBER 1966

YUMA PROVING GROUND
YUMA, ARIZONA

ABSTRACT

The engineering/service desert environmental test of the Foxhole Digging Aid (Interim) was conducted by Yuma Proving Ground, Arizona, during the period 20 June through 11 August 1966.

The purpose of the test was to determine suitability of the test item for desert use.

Interdependent tests were conducted to determine procedures for handling duds, ruggedness and reliability (air drop), operational characteristics and capabilities. The program was divided into three phases: a period of exposure, air drop and firing. Testing was conducted under summer conditions of extreme temperatures on four representative types of desert terrain.

Five shortcomings were noted which did not seriously impair the operation of the item.

It was concluded that the proposed procedures for handling duds were safe and effective, that the item is suitable for low velocity air drop, that the plastic connection on the cratering charge is suitable for use in the desert summer environment, that personnel can exert sufficient hand force to initiate the explosive, that utilization of two test items is a suitable means for generating an acceptable excavation in desert soil, and that the test item will not contaminate the drop zone after malfunction air drop when the item is rigged in a horizontal position. It was recommended that the procedures developed for handling duds at YPG be incorporated into those proposed by Picatinny Arsenal, that the packages be rigged for air drop with the items in a horizontal attitude, that care be exercised when assembling a cratering charge that has been exposed to extreme heat over an extended period of time, and that the cratering charge be tapered for easier use in the field.

FOREWORD

Yuma Proving Ground was responsible for test execution and preparing the test report.

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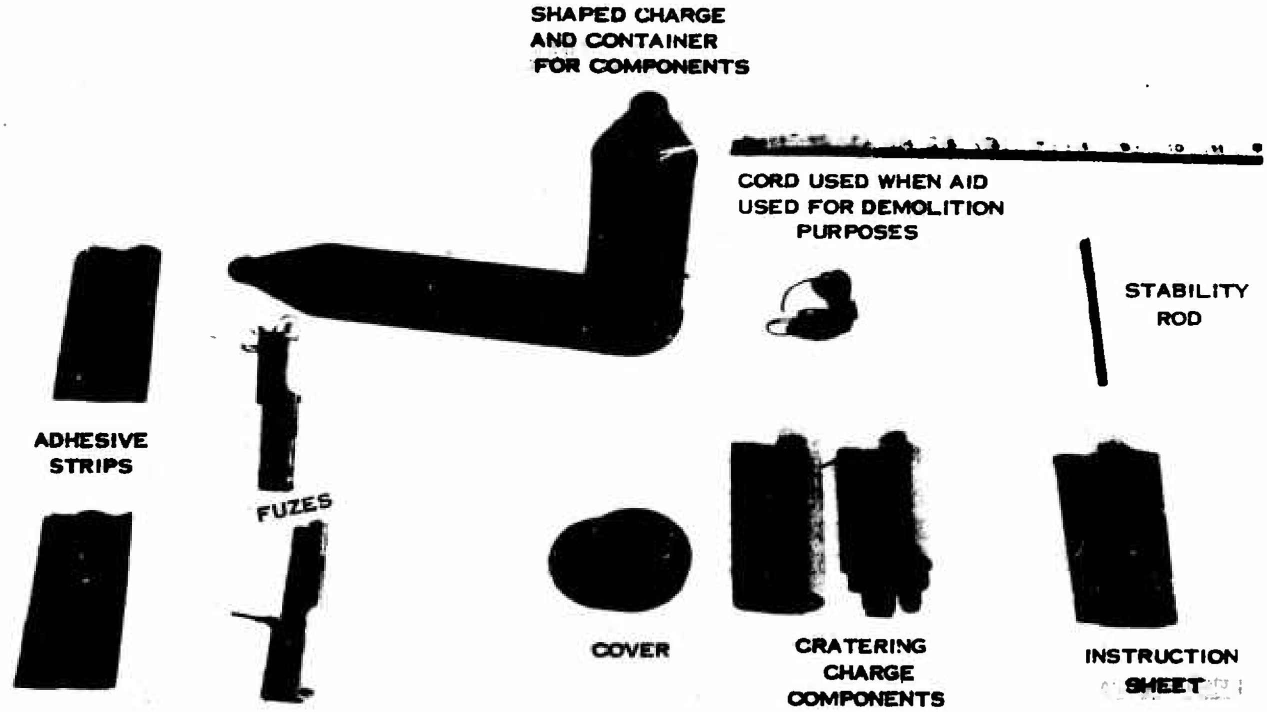


Frontispiece: Foxhole Digging Aid Components.

SECTION 1. INTRODUCTION

1.1 BACKGROUND

There has long been a requirement for a lightweight device capable of assisting the individual soldier to dig rapidly protective shelters and emplacements. For this purpose, the U.S. Army Engineer Research and Development Laboratories (USAERDL) developed a one-operation explosive device employing a shaped charge and a rocket-driven cratering charge. This device, although representing the most advanced state-of-the-art, was not approved for type classification primarily due to its size and weight as compared to its excavating capability.

Subsequently, USAERDL, in an effort to demonstrate feasibility evolved a two-operation explosive device. This was identified as the Foxhole Digging Aid (Interim) (Frontispiece). While incapable of excavating a completed foxhole, this device would aid the soldier considerably.

In order to provide the soldier with an interim assistance, while a foxhole digging aid is developed, revised QMR's and MC's were prepared (Ref f, App VI) by USCONARC and submitted to OCRD.

To expedite the development, a contract was awarded for engineering design of an interim device and for fabrication of a limited number of experimental models.

The Foxhole Digging Aid (Interim) was subjected to desert environmental tests at Yuma Proving Ground during the summer of 1965. Results are contained in YPG Report 5028, January 1966 (Ref e, App VI). As a result of these tests, it was determined that additional information was necessary in order to provide a more complete evaluation of the item.

Further testing of the item was directed by USATECOM letter dated 18 March 1966 inclosed with the final report. This was accomplished during the summer of 1966 and the results are contained in the following report.

1.2 DESCRIPTION OF MATERIEL

The Foxhole Digging Aid (Interim) is a two-operation explosive device consisting of a small shaped charge, a segmented cylindrical cratering charge, and firing components, all packaged in a container approximately 2 inches in diameter and 8 inches in length, and weighing slightly more than 1 pound.

1.3 OBJECTIVES

To conduct additional desert environmental tests to determine:

a. The effectiveness of the draft procedures for handling duds as proposed by the EOD Center, Picatinny Arsenal (App II).

b. Suitability of the test item to withstand low velocity and malfunction air drop (Ref h, App VI).

c. Suitability of the plastic connection on the cratering charge (Ref h, App VI).

d. The ability of personnel to exert sufficient hand force on the activator button to initiate the explosive (Ref h, App VI).

e. Suitability of the test item to perform in desert soils utilizing two, rather than one, foxhole digging aids for excavation (Ref h, App VI).

1.4 SUMMARY OF RESULTS

a. The procedures for handling duds as proposed by the EOD Center, Picatinny Arsenal, including additional procedures as developed through YPG tests, were adequate for destruction of simulated duds in various configurations as would be encountered in field conditions (Para. 2.2.3 and 2.2.4).

b. The test item when rigged and air dropped with a malfunctioning parachute did not function or detonate upon impact (Para. 2.3.3 and 2.3.4).

c. When the test item is rigged for low velocity air drop from the U-1A Army aircraft, the G-13 cargo parachute normally positioned on top of the load must be positioned on the end of the load (Para. 2.3.3 and 2.3.4).

d. The test item did not contaminate the drop zone after impact under parachute malfunction conditions when rigged for air drop with the test items in a horizontal position (Para. 2.3.3 and 2.3.4).

e. The low velocity air drop did not cause damage to the test items or adversely affect their functioning characteristics (Para. 2.3.3 and 2.3.4).

f. Although the plastic connector on the cratering charge did harden during prolonged exposure to extreme heat, it did not crack when the components were assembled (Para. 2.4.3 and 2.4.4).

g. The average force required to initiate the fuze was above the maximum limit of 10 pounds specified by the QMR (Para. 2.5.3 and 2.5.4).

h. Two foxhole digging aids did generate an excavation in desert soils which satisfied the dimensional specifications of the QMR (Para. 2.6.3 and 2.6.4).

i. The shaped charge did not consistently generate an effective pilot hole and the operator frequently experienced difficulty inserting the cratering charge because the hole lacked sufficient depth or a cave-in occurred (Para. 2.6.3 and 2.6.4).

j. Implements such as a spoon or rod rendered the operator very little assistance in forming an effective pilot hole or emplacing the cratering charge (Para. 2.6.3 and 2.6.4).

k. Four duds (4.9 per cent) occurred during the test (Para. 2.6.3 and 2.6.4).

1.5 CONCLUSIONS

a. The draft procedures for handling duds as proposed by the EOD Center, Picatinny Arsenal, including additional procedures developed through testing at YPG are a safe and effective means of disposing of duds under field conditions.

b. The test item is suitable for low velocity air drop and will withstand malfunction air drop.

c. The test item will not contaminate the drop zone after malfunction air drop when the item is rigged in a horizontal position.

d. The plastic connection on the cratering charge is suitable for use in the desert summer environment.

e. Personnel can exert sufficient hand force to initiate the explosive even though the average force of 17 pounds does exceed the QMR requirements.

f. Although the operator frequently experienced difficulty emplacing the cratering charge, utilization of the two foxhole digging aids is a suitable means for generating an excavation of acceptable dimensions in desert soils.

1.6 RECOMMENDATIONS

a. That procedures developed through testing at YPG be incorporated with the draft procedures for handling duds as proposed by the EOD Center, Picatinny Arsenal.

b. That the package be rigged for air drop such that the items are in a horizontal attitude.

c. That care be exercised when assembling a cratering charge which has been exposed to extreme heat over an extended period of time to prevent possible cracking of the plastic connector.

d. That the cratering charge be tapered in order that it might be inserted into the pilot hole more easily.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

The following subtests have been conducted to supplement that contained in YPG Report 5028 of January 1966. Procedures as directed by USATECOM through correspondence (Ref h and i, App VI) and the original test plan were used for guidance.

Fifty-two items were received from Alaska on 21 April 1966 for testing at Yuma. These items were inspected, numbered and grouped for the various test phases (Table I, App I).

2.2 PROCEDURES FOR HANDLING DUDS

2.2.1 Objective

To determine the effectiveness of the draft procedures for handling duds as proposed by the Explosive Ordnance Disposal Center at Picatinny Arsenal.

2.2.2 Method

Items were tested in accordance with instructions contained in Reference i, Appendix VI. A barrier of sandbags was placed around the simulated duds (Fig. 1 and 2, App III). Three witness boards were placed 45 feet from the point of detonation at 90 degree intervals (Fig. 3, App III). The witness board indicated the degree of hazard at this point and assisted in determining a safe distance limit for personnel. The firing sequence, position of sandbags and witness boards are listed in Table 2, Appendix I.

2.2.3 Results

The detonation of the cratering element dislodged the fuze activator from the charge in all test trials and configurations (Table 2, App I). Although the fuze became dislodged, it did not always function. The shaped charge would fracture as a result of the explosion and on one occasion it was found approximately 100 feet from the point of detonation. Fractured shaped charges and fuzes that failed to function were burned. All cratering charges functioned when simulated as duds. No marks appeared on the witness boards placed at locations where personnel would have taken cover (Fig. 4, App III). Fragments were stopped by the sandbag barrier and were found at the base of the sandbags.

2.2.4 Analysis

Whenever possible, the cratering charge used to destroy the dud should be positioned such that it will afford personnel maximum

protection from flying debris. To accomplish this, the cratering charge must be placed between the dud and the barrier (Fig. 5, App III). The barrier should consist of at least three sandbags placed in an upright position and a maximum of 2 feet from the dud. Personnel should take cover a minimum distance of 45 feet from the dud so that the barrier is between personnel and the point of detonation.

The above procedures developed through testing at YPG should be incorporated into the draft procedures for handling duds as proposed by the EOD Center, Picatinny Arsenal.

2.3 RUGGEDNESS AND RELIABILITY (AIR DROP) TESTS

2.3.1 Objectives

a. To determine the suitability of the test item to withstand low velocity and malfunction air drop.

b. To determine if the ground impact resulting from a parachute malfunction would cause the test item to function or contaminate the drop zone.

c. To satisfy the recommendation stated in YPG Report 5028 (Ref e, App VI) that additional aerial delivery tests should be conducted with the items in normal packing configuration.

2.3.2 Method

Packaging techniques employed with the shipping containers were simulated by packaging items and ballast in an identical configuration as provided by the manufacturer (Fig. 6, App III). The wooden overpack containing the test items was rigged on its side to insure horizontal impact of the test item (Fig. 7, 8, 9, App III).

Three air drops were conducted, one using low velocity air drop techniques and two using intentional malfunction drop conditions (Table 3, App I). All air drops were conducted from a U.S. Army U-1A aircraft flying at 80 KIAS at an absolute altitude of 1500 feet. The dimensions of the package were checked to determine if suitable for aerial delivery from U-1A aircraft. Gravity ejection from the door of the aircraft was used in delivering all loads. Impact velocity measurements were obtained by use of cinetheodolite instrumentation, and impact acceleration magnitude data were obtained on selected air drops by using crushable ceramic pellet accelerometers.

After air drop, all samples dropped at low velocity rate of descent were fired for functional suitability test and the results compared with that from firing control items which had not been air dropped (Table 5, App I).

Air drop no. 1 consisted of test items 16A through 20A packaged in the standard wooden container of 40 items (Fig. 7, App III). Thirty-five ballast items were positioned in the package to simulate the actual packaged configuration (Fig. 6, App III). The wooden shipping package containing the test items was rigged on four ammunition boxes filled with ballast to simulate a typical 500-pound A-7A container load. Paper honeycomb 6 inches thick was positioned under the load. The gross weight was 520 pounds. A single G-13 cargo parachute was used for retardation (Fig. 7, App III).

Air drops no. 2 and 3 each consisted of the test items packaged in the same configuration as in air drop. A 68-inch pilot parachute reefed closed was used to stabilize each load for simulation of parachute malfunction (Fig. 8, and 9, App III).

2.3.3 <u>Results</u>

On air drop no. 1 the test items were recovered with no damage incurred (Table 5, App I and Fig. 10, App III). No adverse effects were noted when the items were subjected to subsequent functional tests (Table 5, App I).

On air drops no. 2 and 3 and test items remained intact (Table 5, App I and Fig. 11 and 12, App III). No exposed propellant was visible. No detonation or fire occurred. The test items were disposed of in place.

No difficulties were noted in ejecting all loads from U-1A aircraft.

2.3.4 <u>Analysis</u>

The package should be rigged for air drop so that the items are in a horizontal attitude to prevent possible detonation upon impact. In case of a prarchute malfunction, damaged items should be disposed of in place. The U.S. Army U-1A aircraft may be utilized for aerial delivery of this item.

2.4 OPERATIONAL CHARACTERISTICS

2.4.1 <u>Objective</u>

To determine the suitability of the plastic connection on the cratering charge when the item is stored and operated in a desert summer environment.

2.4.2 Method

Ten test items were exposed to desert summer environment for a period of 45 days (Table 1, App I). Visual inspections were made before and after exposure and comparisons were made with items placed in constant temperature storage ($70\pm5°F$). Particular attention was paid to the condition of the plastic connector. During the final phase of testing observations were made to determine if the condition of the plastic connector would adversely affect the assembly or functioning of the item.

2.4.3 Results

Exposure of the test items to desert summer environment caused the plastic connector to harden somewhat. However, the connector did not crack during the assembly operation. This did not significantly hinder the assembly procedure of the cratering charge. The functioning of the cratering charge was not adversely affected (Table 5, App I).

2.4.4 Analysis

Since the plastic connector on the cratering charge may become hard and in some cases brittle after prolonged open storage to desert summer environment care should be exercised when assembling this component. Hasty assembly of this component or the use of unnecessary force may cause the plastic connector to crack (Ref e, App VI). Should the connector crack one of the adhesive strips inclosed with the package may be used to attach the two components.

2.5 OPERATIONAL CAPABILITIES I

2.5.1 Objective

To determine the ability of personnel to exert sufficient hand force on the activator button to initiate the explosive.

2.5.2 Method

The force required to depress the activator button was measured with a mechanical force gage at various times during the final phase of the test (Fig. 13, App III). Data including appropriate comments by operating personnel were noted (Tables 4 and 5, App I).

2.5.3 Results

The average force as determined from 43 measurements taken during the test was 17 pounds. Thirty-two of the 43 measurements were above 15 pounds, the maximum force permitted by the QMR (Table 4, App I). On four occasions, the operator commented that he experienced difficulty depressing the activator button; the operator either had to exert more

force than usual or the button broke (Tables 4 and 5, App I). In most cases the operator depressed the button without difficulty.

2.5.4 Analysis

The number of occasions (four) when the operator experienced difficulty is insignificant considering the total number of test trials (82). Table 6 of Appendix I shows the distribution of the 82 trials.

2.6 OPERATIONAL CAPABILITIES II

2.6.1 Objective

To determine the suitability of the test item to perform in desert soils utilizing two, rather than one, foxhole digging aid for excavation.

2.6.2 Method

The items were divided into four groups (Table 1, App I) to be tested at the same sites used previously (Ref e, App VI). Two test items were selected for each test excavation. The first item was detonated in the conventional manner, loose dirt removed and measurements taken (upper diameter, lower diameter and depth). The second item was emplaced at the base of the first hole and detonated (Fig. 14, App III). The loose soil was again removed and measurements taken. Any occurrence of duds during the test was noted.

2.6.3 Results

All dimensional requirements were met when two foxhole digging aids were utilized to generate the excavation (Table 5, App I). The shaped charge generally did not produce useful or well defined pilot holes when used on the ground surface in the conventional manner. When emplaced at the base of the original hole during the secondary phase of excavation it displayed even poorer performance (Fig. 15, App III). Usually the operator had to force the cratering charge into the pilot hole and frequently a portion was above the ground surface (Fig. 16 App III). Frequently the operator experienced difficulty emplacing this charge due to the fact that the charge has a blunt end (see Frontispiece). A spoon or rod provided only limited assistance in emplacing the cratering charge or improving the dimensions or definition of the pilot hole (Fig. 17, App III). Four duds (4.9 per cent) occurred during the test (Table 6, App I).

2.6.4 Analysis

The nature of desert terrain renders it difficult to form an effective pilot hole with a shaped charge and utilization of such

implements as a spoon or rod provides little assistance in forming a more effective hole or in emplacing the cratering charge. Cave-in's are a particular problem in desert terrain.

Usually the cratering charge must be forced into the pilot hole and frequently a portion remains above the ground surface. The cratering charge should be tapered in order that it might be inserted into the pilot hole more easily.

SECTION 3 - APPENDICES

APPENDIX I. TEST DATA

TABLE 1. Allocation of Test Devices

Test Item No.	Control (70+5°F)	45-Day Exposure	Magazine Storage	Air Dropped	Desert Pavement (Gp 1)	Wash Beds (Gp 2)	Scoriac Deposit and Malpais (Gp 3)	Dunes Areas (Gp 4)	Dud Handling Procedures	Initiation Load
1A		X			X					X
2A		X			X					X
3A		X			X					
4A		X				X				X
5A		X				X				
6A		X					X			X
7A		X					X			
8A		X					X			X
9A		X					X			X
10A		X						X		X
11A	X				X					X
12A	X				X					X
13A	X					X				X
14A	X						X			X
15A	X							X		X
16A			X	X	X					X
17A			X	X	X					X
18A			X	X		X				X
19A			X	X			X			
20A			X	X				X		X
21A			X	X						
22A			X	X						
23A			X	X						
24A			X	X						
25A			X	X						
26A			X	X						
27A			X	X						
28A			X	X						
29A			X	X						
30A			X	X						
31A			X		X					X

TABLE 1. Allocation of Test Devices (Concluded)

Test Item No.	Control (70±5°F)	45-Day Exposure	Magazine Storage	Air Dropped	Pavement (Gp 1)	Wash Beds (Gp 2)	Scoriac Deposit and Malpais (Gp 3)	Dunes Areas (Gp 4)	Dud Handling Procedures	Initiation Load
32A			X		X					
33A			X		X					X
34A			X			X				X
35A*			X					X		
36A			X				X			X
37A			X				X			
38A			X				X			X
39A			X				X			X
40A			X					X		X
41A			X		X				X	
42A			X		X				X	
43A			X		X				X	
44A			X		X				X	
45A			X		X				X	
46A			X		X				X	
47A			X		X				X	
48A			X		X				X	
49A			X		X				X	
50A			X		X				X	
51A			X		X				X	
52A			X			X			X	

*Extra test item, detonated at end of test as part of documentary film coverage.

TABLE 2. Procedures for Handling Duds, Field Test Data

Test No.	Test Item No.	Configuration	Remarks
1	41A	Shaped charge w/o fuze, upright sandbag barrier, no witness board	Shaped charge fractured.
2	42A	Shaped charge w/o fuze, horizontal sandbag barrier, no witness board	Shaped charge fractured.
3	43A	Shaped charge with fuze, horizontal sandbag barrier, no witness board	Shaped charge fractured, fuze dislodged but not destroyed
4	44A	Shaped charge with fuze, upright sandbag barrier, no witness board	Shaped charge fractured and displaced approximately 100 feet from point of detonation, fuze dislodged and destroyed
5	45A, 46A	Cratering charge w/o fuze, sandbag barrier, no witness board	Dud completely destroyed
6	47A, 48A	Cratering charge with fuze, sandbag barrier, no witness board	Dud including fuze, completely destroyed.
7	49A	Shaped charge with fuze, upright sandbag barrier, witness boards (3) placed at 90° intervals and 45 feet from point of detonation	Shaped charge fractured, fuze dislodged and destroyed, no marks on witness board positioned where personnel would take cover.
8	50A	Shaped charge with fuze, upright no barrier, witness boards (3) placed at 90° intervals and 45 feet from point of point of detonation	Shaped charge fractured, fuze dislodged and destroyed, no marks on witness board positioned where personnel would take cover.
9	51A	Cratering charge w/o fuze, no barrier, witness boards (3) placed at 90° intervals and 45 feet from point of detonation	Dud completely destroyed, no marks on witness board positioned where personnel would take cover.

TABLE 3. Summary of Air Drop Test Data

Air Drop No.	Test Item No.	Type Container	Parachute	Wt (lb)	Imp Vel System	Remarks
1	16A, 17A, 18A, 19A, 20A	A-7A	G-13 cargo	520	Low	No damage
2*	21A, 22A, 23A, 24A, 25A	A-7A	68 in. Pilot reefed	500 (Approx)	Malfunction	Items intact No fire or deton-ation. No exposed propellant visible
3*	26A, 27A, 28A, 29A, 30A	A-7A	68 in. Pilot reefed	500 (Approx)	Malfunction	Items intact No fire or deton-ation. No exposed propellant visible

Drop No.	Opening Time	Down Time (sec)	Impact Velocity (ft/sec)	A/C Release Velocity (ft/sec)	Aircraft Release Altitude (ft)	Azimuth of Aircraft at Release (degrees-minutes)	
1	3.8	28.4	30.5	147.11	1536.1	238	30
2	NA	9.8	223.2	138.0	1621.0	233	16
3	NA	9.6	178.9	147.09	1540.1	240	10

*The test items were disposed of in place.

TABLE 4. Initiation Load, Force Data

Test No.	Test Item No.	Conditioning	Handling	Test Area	Force (lb)*	Remarks
1	11A	Control	--	Desert Pavement	18	Avg. force, control group, 17 lb
2	11A	Control	--	Desert Pavement	17	
3	12A	Control	--	Desert Pavement	22	
4	1A	Exposed	--	Desert Pavement	22	
5	1A	Exposed	--	Desert Pavement	18	
6	2A	Exposed	--	Desert Pavement	12	
7	2A	Exposed	--	Desert Pavement	22	
8	31A	Magazine Storage	--	Desert Pavement	16	Avg. force magazine storage group 16 lb
9	31A	Magazine Storage	--	Desert Pavement	14	
10	33A	Magazine Storage	--	Desert Pavement	13	Dud
11	17A	Magazine Storage	Air Drop	Desert Pavement	16	
12	17A	Magazine Storage	Air Drop	Desert Pavement	16	
13	16A	Magazine Storage	Air Drop	Desert Pavement	16	Dud
14**	--	--	--	Desert Pavement	16	Avg. force tests no. 14-24, 17lb
15	--	--	--	Desert Pavement	18	
16	--	--	--	Desert Pavement	15	
17	--	--	--	Desert Pavement	16	
18	--	--	--	Desert Pavement	18	
19	--	--	--	Desert Pavement	18	
20	--	--	--	Desert Pavement	19	
21	--	--	--	Desert Pavement	18	
22	--	--	--	Desert Pavement	18	
23	--	--	--	Desert Pavement	16	
24	--	--	--	Desert Pavement	14	
25	34A	Magazine Storage	--	Wash Bed	14	
26	34A	Magazine Storage	--	Wash Bed	14	Dud

TABLE 4. Initiation Load, Force Data (Concluded)

Test No.	Test Item No.	Conditioning	Handling	Test Area	Force (lb)*	Remarks
27	18A	Magazine Storage	Air drop	Wash Bed	13	Avg. force air dropped group, 16 lb
28	13A	Control	--	Wash Bed	13	
29	4A	Exposed	--	Wash Bed	18	
30	36A	Magazine Storage	--	Scoriac Deposit and Malpais	18	
31	38A	Magazine Storage	--	Scoriac Deposit and Malpais	22	
32	39A	Magazine Storage	--	Scoriac Deposit and Malpais	16	
33	6A	Exposed	--	Scoriac Deposit and Malpais	16	Avg. force exposed group, 18 lb
34	6A	Exposed	--	Scoriac Deposit and Malpais	18	
35	14A	Control	--	Scoriac Deposit and Malpais	14	
36	14A	Control	--	Scoriac Deposit and Malpais	19	
37	8A	Exposed	--	Scoriac Deposit and Malpais	19	
38	8A	Exposed	--	Scoriac Deposit and Malpais	16	
39	9A	Exposed	--	Scoriac Deposit and Malpais	19	
40	15A	Control	--	Dune Area	17	
41	10A	Exposed	--	Dune Area	21	
42	20A	Magazine Storage	Air Drop	Dune Area	20	
43	40A	Magazine Storage	--	Dune Area	13	

Average Force 17 lb

*Used mechanical force gage, Hunter Spring Co. model L-30-M

**Tests no. 14 through 24 used fuzes not identifiable with any particular test item.

TABLE 5. Firing Data

Test Hole No.	Test Item No.	Excavation Dimensions (in.) Depth	Upper Diameter	Lower Diameter	Remarks
		Desert Pavement			
1	11A	12.0	33.0	13.0	
	12A	19.5	37.0	13.0	R
2	1A	15.0	29.0	9.0	
	2A	22.5	37.0	14.0	Difficult to depress activator button* R
3	17A	21.5	43.0	11.0	
	3A	27.0	48.0	15.0	Good pilot hole
4	31A	14.5	35.0	10.0	S
	32A	23.0	44.0	10.0	
-	33A	--	--	--	Dud, destroyed by EOD
-	16A	--	--	--	Dud, destroyed using cratering charge
		Wash Bed			
1	4A	18.0	52.0	13.0	Difficult to depress activator button S
	5A	22.0	54.0	13.0	Difficult to depress activator button Dud (shaped charge), Emplaced cratering charge and fired.
2	18A	20.0	51.0	15.0	
	52A	23.0	56.0	15.0	
-	13A	--	--	--	Difficult to depress activator button; button broke. Item destroyed by EOD
-	34A	--	--	--	Dud, item destroyed by EOD

TABLE 5. Firing Data (Concluded)

Test Hole No.	Test Item No.	Excavation Dimensions (in.) Depth	Upper Diameter	Lower Diameter	Remarks
		Scoriac Deposit and Malpais			
1	6A	15.0	27.0	12.0	
	7A	19.0	38.0	12.0	
2	14A	15.0	34.0	9.0	
	19A	21.0	37.0	9.0	
3	8A	16.0	31.0	9.0	
	36A	24.0	38.0	12.0	R
4	37A	23.0	40.0	14.0	Good pilot hole
	38A	27.0	44.0	14.0	No shaped charge used
5	9A	14.0	32.0	11.0	
	39A	17.0	34.0	11.0	No shaped charge used
		Dune Area			
1	15A	30.0	53.0	15.0	Good pilot hole
	20A	35.0	58.0	15.0	No shaped charge used
2	10A	18.0	54.0	16.0	
	40A	18.0	56.0	16.0	No shaped charge used
-	35A	--	--	--	Extra test item; detonated at termination of test as part of documentary film coverage.
	Avg -	23.0**	44.5	13.0	

NOTES:
R - a rod was utilized to assist in forming a pilot hole to emplace the cratering charge
S - a spoon was utilized to assist in forming a pilot hole to emplace the cratering charge
* - Force measurement taken, see Table 4, Test No. 4.
** - Considered to have met QMR specifications

TABLE 6. Functioning Data

Subtest	No. Test Items	No. Trials	No. Duds	Remarks
Draft Procedures for handling duds	11	9	0	See Tables 1 and 2
Ruggedness and Reliability (Air Drop) Test (Malfunction Drops)	10	-	-	See Table 3
Operational Capabilities I	-	11	0	Extra fuzes not identifiable with any particular test item. See Table 4
Operational Capabilitie II	31	62*	4	See Table 5
TOTALS	52	82	4 (or 4.9 per cent)**	

*Each item was subjected to two trails (pilot hole formation and the cratering formation phase).
**Requirement not more than 5 per cent.

APPENDIX II. CORRESPONDENCE

COPY

DEPARTMENT OF THE ARMY
Headquarters, U.S. Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland 21005

AMSTE-BC 11 JUL 1966

SUBJECT: Duds Occurring with the Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300

TO: Commanding Officer
USA Engineer Research and Development
Laboratories
ATTN: Combat Engineering Division
Fort Belvoir, Virginia 22060

1. An evaluation of reports received from test agencies/boards indicates the cause of duds with subject aid has been failure of the delay fuze activator to operate. Should duds occur in a combat environment an approved corrective action procedure must be furnished for the use of front line combat troops. In non-combat situations explosive ordnance disposal teams may be called upon to dispose of or render the dud safe.

2. In an effort to provide the combat solider with a procedure for rendering the dud safe, the Explosive Ordnance Disposal Center at USA Picatinny Arsenal has furnished this headquarters with the following procedure. This procedure has been tested by Yuma Proving Ground and determined to be satisfactory.

3. Procedure (when Explosive Ordnance Disposal personnel are not available):

a. Dud occurring when using shaped charge.

(1) Wait 30 minutes before approaching the dud (if not possible in a combat situation, wait a minimum of five minutes).

(2) Do not touch or disturb in any manner (shaped charge, cratering charge, surrounding soil, etc).

(3) Position cratering charge with longitudinal axis parallel to the longitudinal axis of the shaped charge so that the top of both charges are approximately in line. Position the charges so they do not touch and at a maximum distance of 6 inches apart. NOTE: Cratering charge can be tied or taped (material furnished with aid) to a stick put in the ground in proper vertical position. NOTE: If the malfunctioned shaped charge is lying on the ground, place the cratering charge on the ground (maximum 6 inches distance) so that the top of both charges are approximately in line. Stay clear of direction of the jet (open end of shaped charge) at all times. Cratering charge should be placed between the dud and the barrier.

(4) Sandbag or barricade. Barrier should be 1½ feet high (minimum) and 2 feet from dud (maximum).

(5) Initiate cratering charge.

(6) Personnel will assume prone position a minimum of 15 yards from the dud so that the barrier is between man and detonation.

(7) If resultant explosion fails to detonate the shaped charge but does cause fracturing of the shaped charge casing and dislodging of the delay fuse activator, the shaped charge casing may be carried away and burned or buried. If the delay fuze activator is located, do not approach for 30 minutes (if not possible in a combat situation, wait a minimum of five minutes). The delay fuze can then be burned or buried.

b. Dud occurring when using cratering charge.

Repeat 3a(1), (2), (4) and (6) placing a second cratering charge in the same hole as the dud.

4. It is recommended that the above procedure be published as a part of the operating instructions issued with the Foxhole Digging Aid.

FOR THE COMMANDER:

AUSTIN TRIPLETT, Jr.
Colonel GS
Dir, Inf Mat Test

Copies furnished:
CO, APG, ATTN: STEAP-DS
CO, YPG
CO, USAATC
CO, USATTC
Pres, USAIB

DEPARTMENT OF THE ARMY
Headquarters, U.S. Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland 21005

AMSTE-BC 22 JUL 1966

SUBJECT: Change to Procedures for Handling "Duds" with the Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300

TO: Commanding Officer
USA Engineer Research &
Development Laboratories
ATTN: Combat Engineering Div
Fort Belvoir, Virginia 22060

1. Reference letter, AMSTE-BC, Hq USATECOM, 11 Jul 66, subject: Duds Occurring with the Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300.

2. Make the following changes in reference letter:

a. Para 3a(1) and (7) - Delete "(if not possible in a combat situation, wait a minimum of five minutes)".

b. Para 3a(3) - Delete and add: "Dud may be destroyed by placing another foxhole cratering charge parallel to the dud, not touching nor more than 6 inches apart. The cratering charge can be tied to a stick placed in the ground if standing in a vertical position. Stay clear of the open end of the shape charge jet."

c. Para 3a(4) - Delete and add: "Place sandbags or barricade between dud and personnel. Barrier should be 1½ feet high, 3 feet long and 2 feet from dud."

FOR THE COMMANDER:

/s/ Austin Triplett, Jr.
/t/ AUSTIN TRIPLETT, Jr.
Colonel GS
Dir, Inf Mat Test

Copies furnished:
CO, APG, ATTN: STEAP-DS
CO, YPG
CO, USAATC
Pres, USAIB

APPENDIX III. PHOTOGRAPHS

FIGURE 1. Cratering charge in position to destroy a simulated dud (cratering charge).

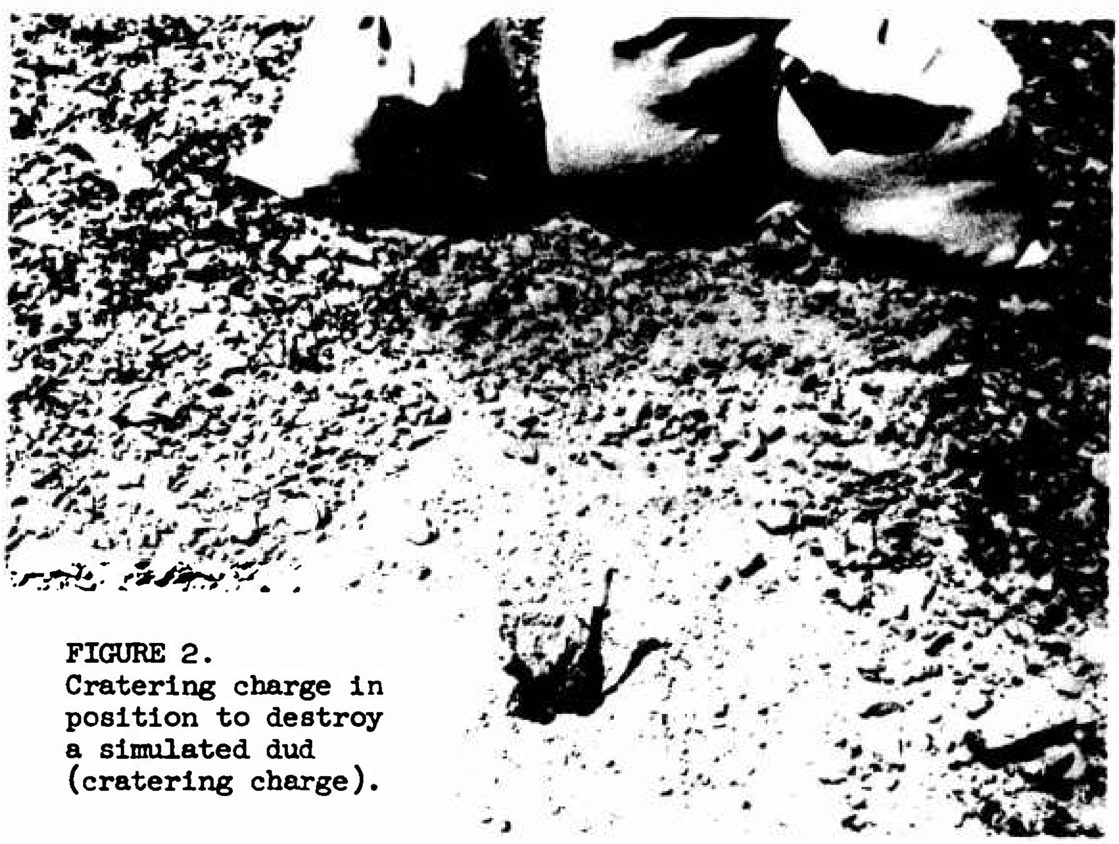


FIGURE 2.
Cratering charge in position to destroy a simulated dud (cratering charge).

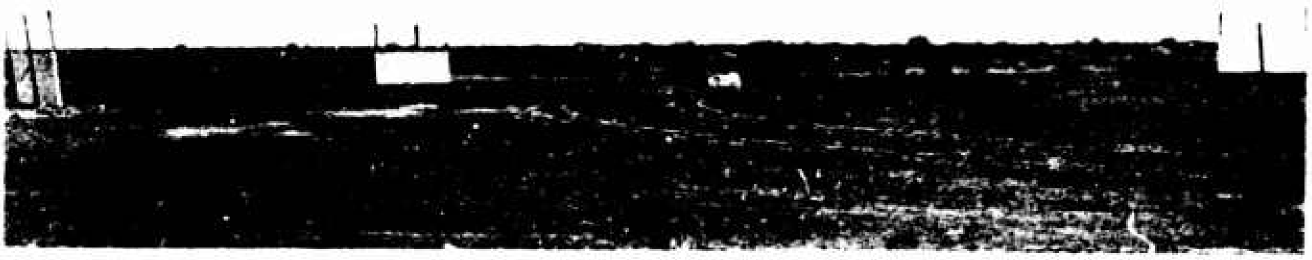


FIGURE 3. Testing of proposed dud handling procedures. Note three witness boards located 45 feet from point of detonation at 90-degree intervals. The witness board at the left represents where personnel would take cover.

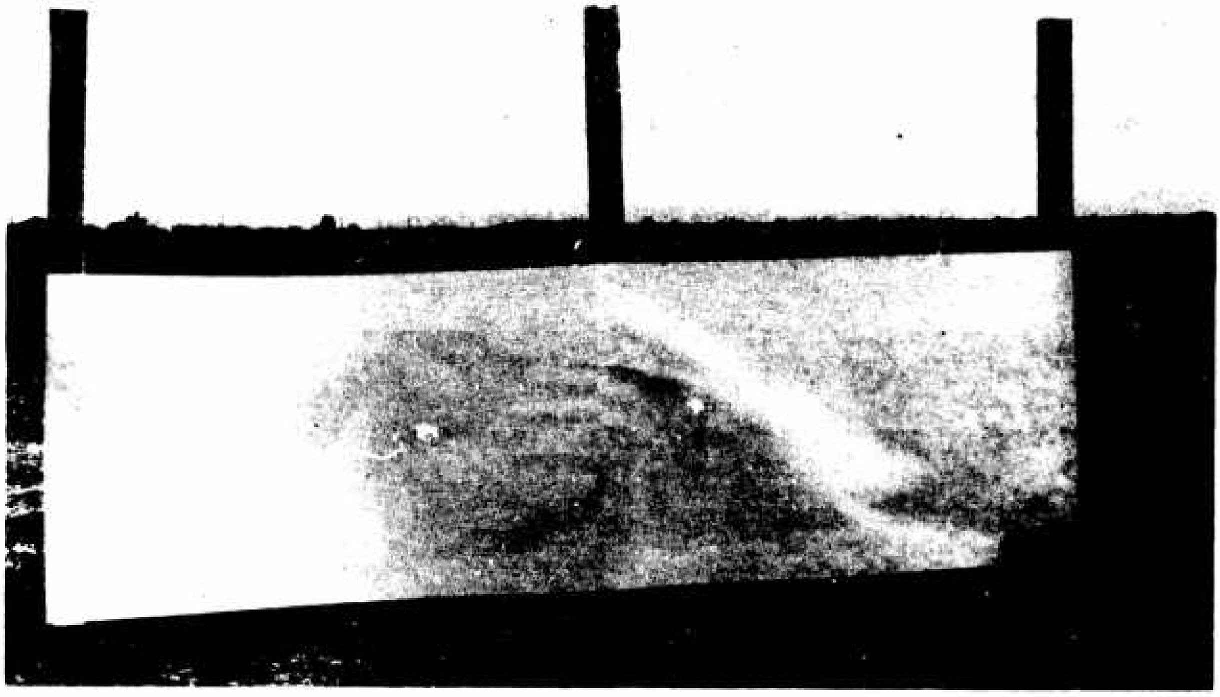


FIGURE 4. Condition of witness board after destruction of the simulated dud (shaped charge with fuze, round 49A). Note absence of any marks or holes in witness board indicating the area is safe.

FIGURE 5. Cratering charge in position to destroy a simulated dud (shaped charge with fuze). Note sandbag barrier and witness board. The cratering charge is placed between the barrier and the shaped charge such that debris will travel away from the position where personnel would take cover as simulated by the witness board.

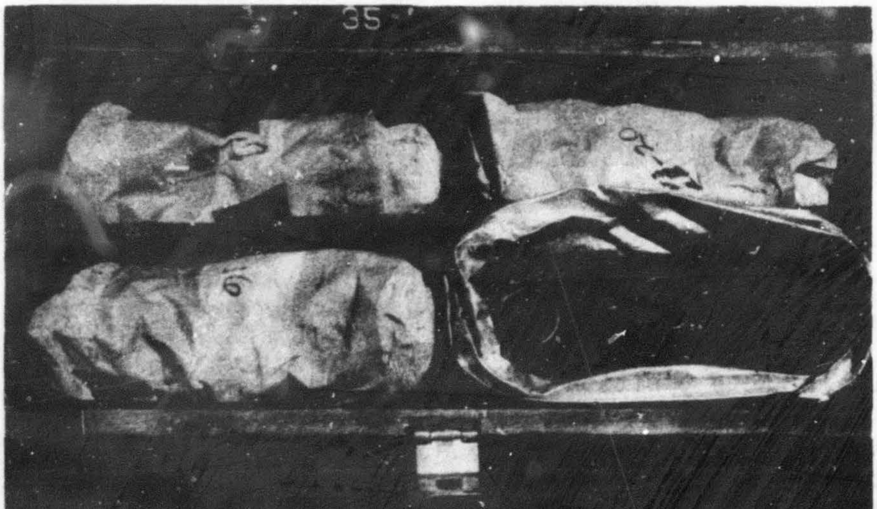
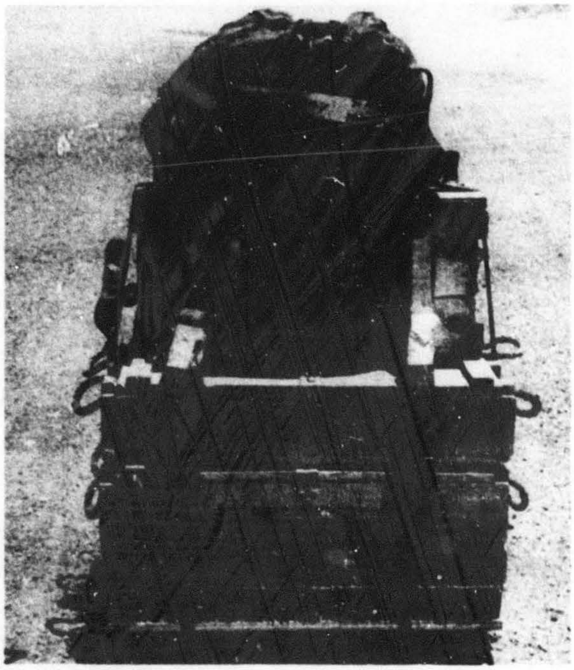


FIGURE 6. Test items as packed for airdrop. The container of 40 units included five test items and 35 simulated items. Note pipe utilized to simulate test items.

FIGURE 7. Before air drop No. 1 (low velocity). Note position of package rigged on its side such that the test items are in a horizontal attitude.



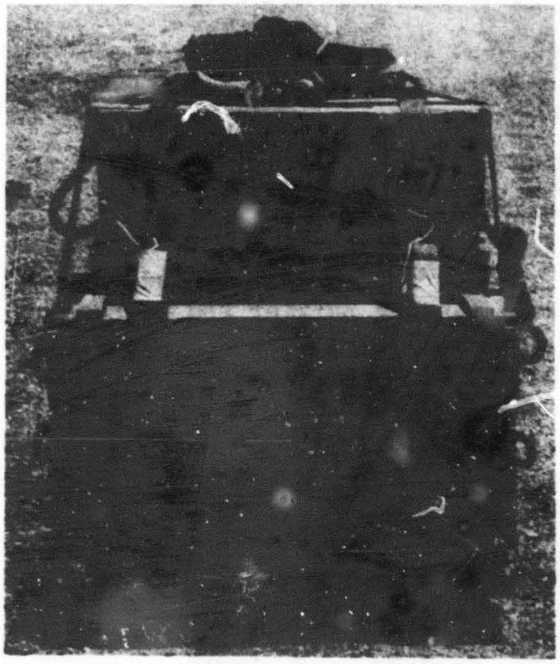


FIGURE 8. Before air drop No. 2 (intentional malfunction). Note position of package rigged on its side such that the test items are in a horizontal attitude.

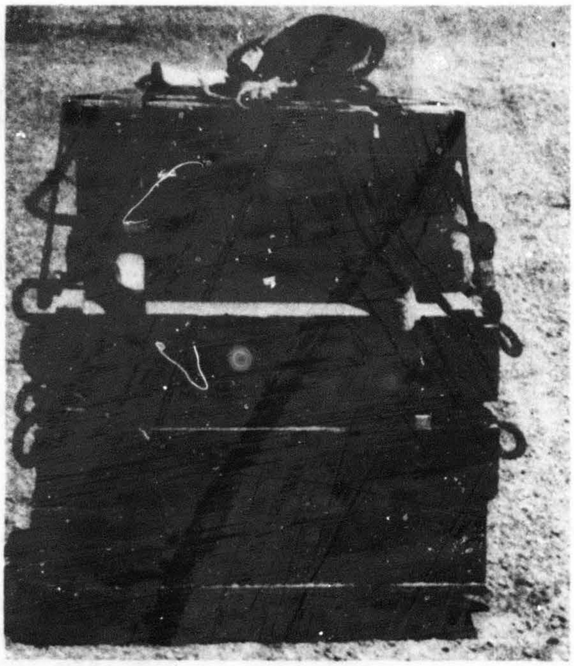


FIGURE 9. Before air drop No. 3 (intentional malfunction). Note position of package rigged on its side such that the test items are in a horizontal attitude.

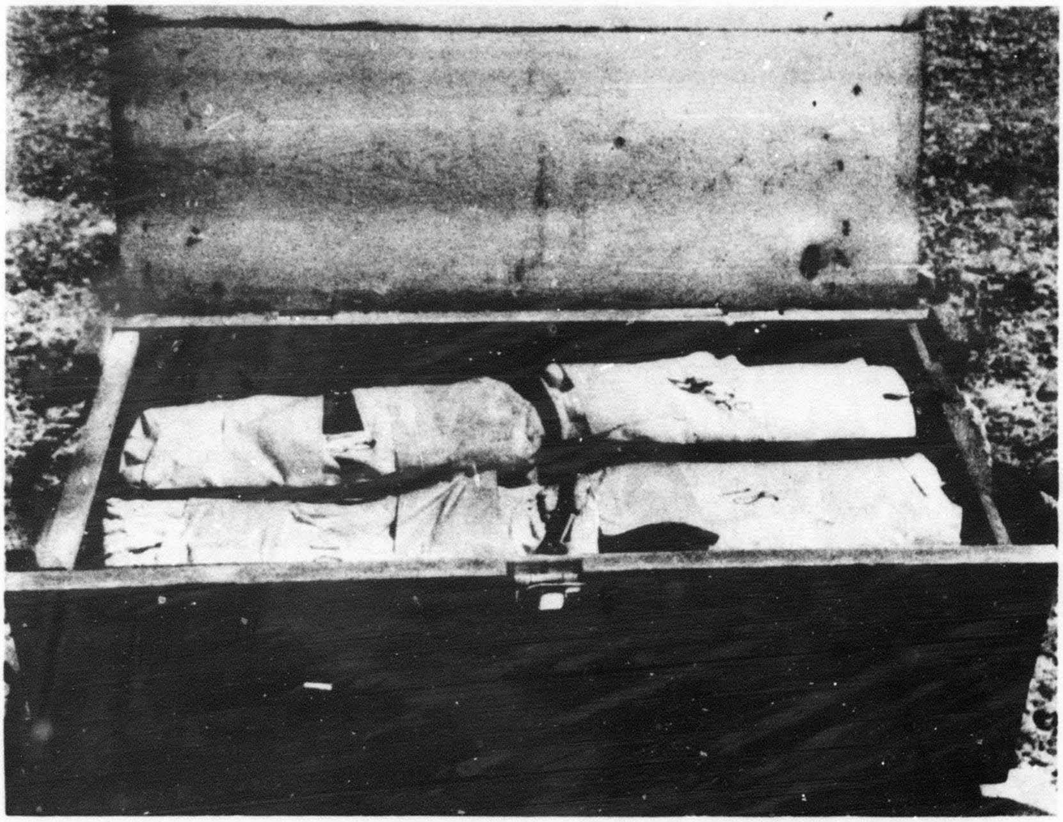


FIGURE 10. After air drop No. 1 (low velocity). TOP: General view.
BOTTOM: Close-up view of item distribution in wooden overpack.

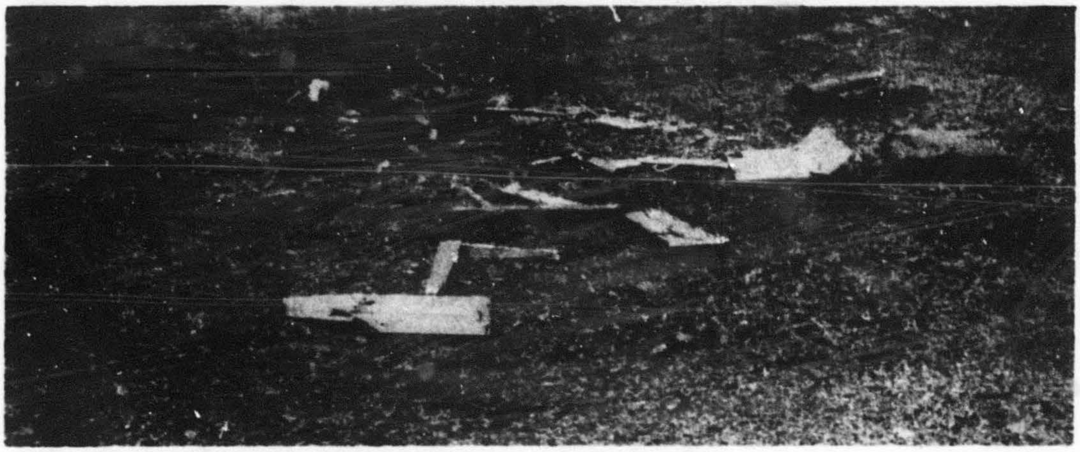


FIGURE 11. After air drop No. 2 (intentional malfunction).

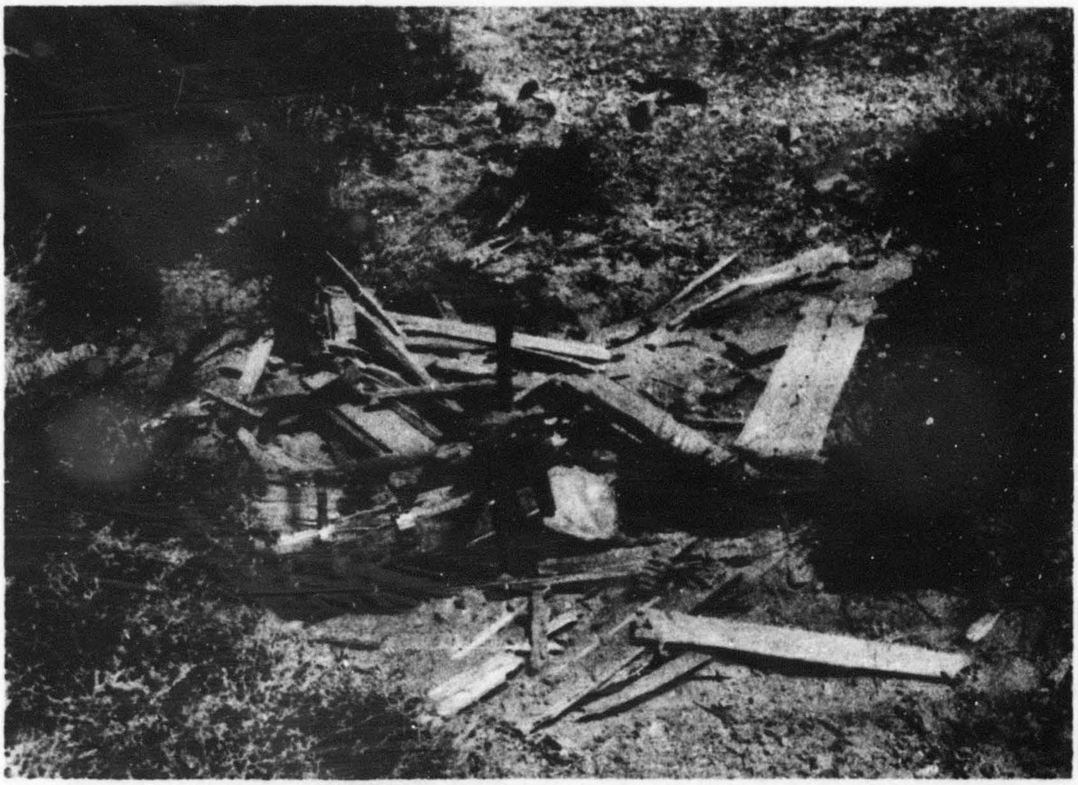


FIGURE 12. After air drop No. 3 (intentional malfunction).

FIGURE 13. Mechanical force gage used to measure initiation load.

FIGURE 14. Cratering charge emplaced at base of original excavation. Note portion of charge above ground surface. Second cratering charge utilized to enlarge the dimensions of the original excavation.

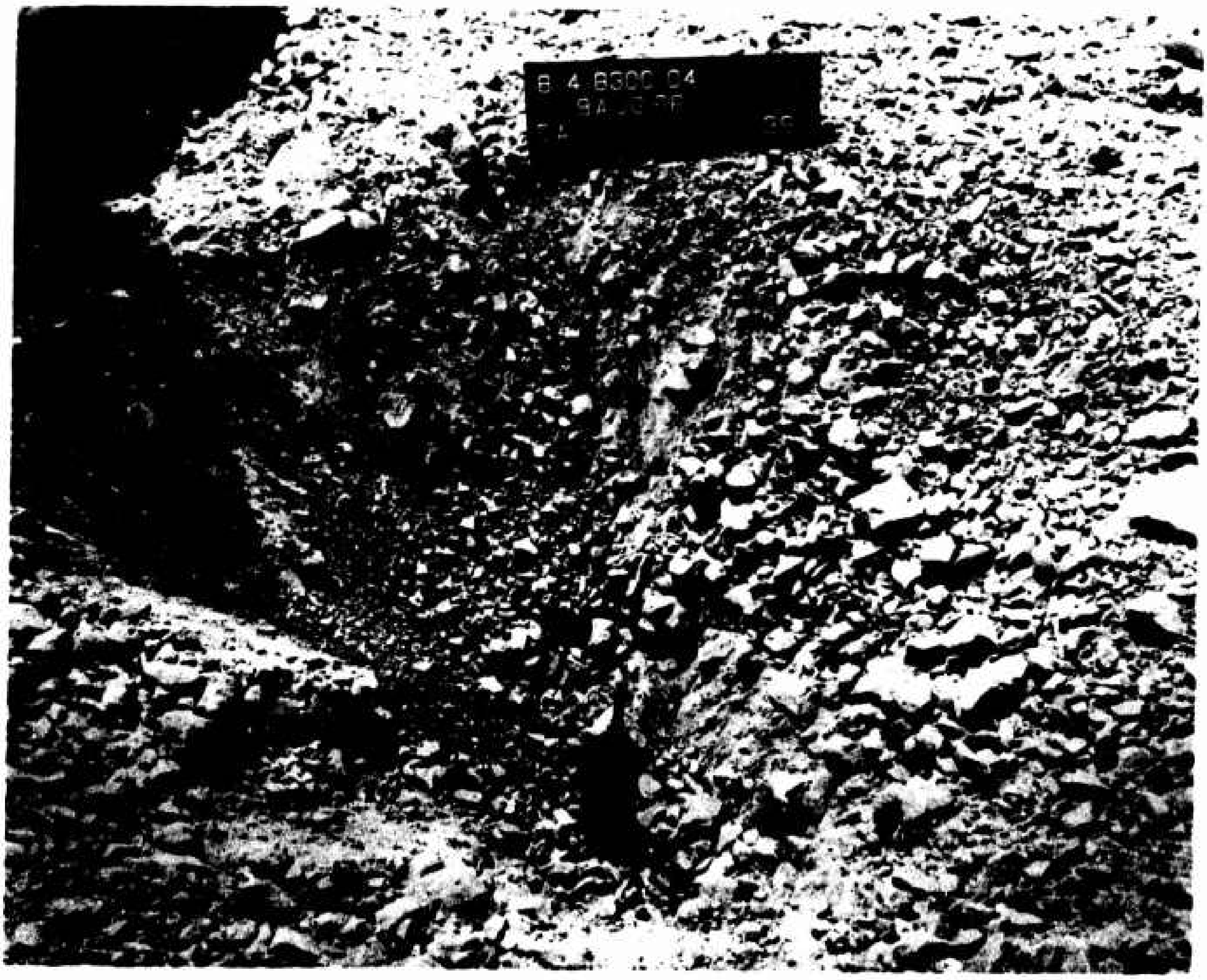


FIGURE 15. Shaped charge placed at base of original excavation to form a second pilot hole.

FIGURE 16. A typical cratering charge emplaced and ready to fire. Note ineffective pilot hole formation. Charge must be forced into hole and a portion remains above the ground surface.

FIGURE 17. [illegible] kit spoon used to assist in forming pilot hole.

SHORTCOMINGS

Shortcoming	Suggested Corrective Action	Remarks
The average force required to depress the activator button was 17 pounds, 2 pounds greater than the maximum QMR specification. Thirty-two of 43 force readings recorded were above 15 pounds.	Change activator assembly such that less force would be required to depress the button. Possibly utilize a different spring or change diameter of the two metal ball components.	Although the average force required to depress the activator button was slightly above the requirement of 15 pounds and the majority of individual readings were above the specification, the operator was able to exert sufficient force to depress the button on all test trials. The operator expressed that he experienced difficulty on relatively few trials (4 out of 82).
The activator button broke during one test trial.	None required.	The operator failed to depress the button such that the entire or major component of force was in one direction, usually the vertical direction. Utilization of the machanical force gage during this trial prevented the operator from exercising the control which would have prevented the incident under normal field operating conditions.
The shaped charge did not consistently generate an effective pilot hole.	Unknown	The type of terrain typical of the desert makes it difficult to form an effective or well defined pilot hole. Cave-in's are a particular problem. The dimensional specifications of the QMR for the excavation were met, however.

SHORTCOMINGS (Concluded)

Shortcomings	Suggested Corrective Action	Remarks
Usually the cratering charge had to be forced into the pilot hole and frequently a portion was above the ground surface.	Taper the cratering charge to permit easier insertion into the pilot hole.	The dimensional specifications of the QMR for the excavation were met.
Four malfunctions (duds) occurred during the firing phase.	Unknown	Percentage of duds was 4.9. The QMR specification of not more than 5 per cent was met.

APPENDIX V. METEOROLOGICAL DATA

45-Day Exposure Period (20 June to 3 August 1966)

Day No.	Ambient Temp (°F) Max.	Min	Avg	Ground Temp (°F) Max.	Min	Avg
1	101	71	88	142	72	101
2	105	76	91	140	75	104
3	102	73	89	135	72	100
4	100	73	88	136	75	101
5	103	72	89	140	72	102
6	106	74	90	140	74	103
7	105	71	90	140	73	103
8	107	74	92	142	76	105
9	105	79	94	138	80	106
10	104	83	92	132	82	102
11	104	80	92	139	81	106
12	107	77	93	139	79	105
13	103	75	91	139	75	103
14	108	75	93	143	76	104
15	109	76	94	145	75	105
16	112	77	95	143	77	106
17	113	79	97	142	78	108
18	98	84	90	105	84	95
19	104	83	92	136	83	104
20	105	83	92	133	83	101
21	105	83	94	143	84	108
22	108	83	96	146	83	109
23	107	83	95	141	80	106
24	108	79	94	146	76	105
25	108	75	94	146	75	107
26	110	80	96	145	82	108
27	106	85	96	144	86	106
28	107	86	97	143	86	108
29	112	85	98	142	84	109
30	103	83	92	146	84	105
31	104	82	93	139	83	106
32	104	82	94	142	84	108
33	104	86	93	141	89	104
34	108	83	97	146	85	110
35	111	86	99	146	89	112
36	105	82	94	142	87	109
37	108	86	97	145	87	111
38	106	84	95	140	87	108
39	98	83	91	125	87	102
40	94	79	87	121	84	95
41	98	83	89	120	85	96
42	101	80	91	125	83	96
43	104	83	94	134	81	103
44	109	86	98	146	86	110
45	110	85	97	146	87	108

APPENDIX VI. REFERENCES

a. Plan of Test for Engineering Service Desert Environmental Test of Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04, 15 July 1964.

b. USAERDL Report 1619, Combat Excavation Tests of Cratering with Explosives, 18 March 1960.

c. USAERDL Report 1742, Phase II of Combat Excavation Tests of Cratering with Explosives, 7 March 1963.

d. First Partial Report of Engineering Test of Foxhole Digging Aid, EL-4 (Interim), Report No. DPS-1598, USATECOM Project No. 8-4-8300-01, Aberdeen Proving Ground, Maryland, March 1965.

e. Final Report of Engineering/Service Desert Environmental Test of Foxhole Digging Aid (Interim), YPG Report 5028, USATECOM Project No. 8-4-8300-04, Yuma Proving Ground, Arizona, January 1966.

f. RDT&E Project Card, Task No. 1D543312D46406, 1 July 1964, with Inclosures (QMR for Foxhole Digging Aid) and Exhibit A (Technical Characteristics).

g. Letter AMSTE-BC, Headquarters USATECOM, subject "Final Report of Engineering/Service Desert Environmental Test of Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04, YPG Report 5028," 28 March 1966. (Authority to conduct environmental tests contained herein.)

h. Letter AMSTE-BC, Headquarters, USATECOM, subject "Final Report of Engineering/Service Desert Environmental Test of Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04, YPG Report 5028," 18 March 1966. (Test objectives contained herein.)

i. Letter AMSTE-BC, Headquarters USATECOM, subject "Additional Testing Required of the Foxhole Digging Aid (Interim), USATECOM Project No. 8-4-8300-04", 3 June 1966. (Authority to conduct air drop testing contained herein.)

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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ENGINEERING/SERVICE DESERT ENVIRONMENTAL TEST OF FOXHOLE DIGGING AID (INTERIM)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Second Final Report, 20 June through 11 August 1966

5. AUTHOR(S) (Last name, first name, initial)
Schoudel, Walter E., Sp5
Scientific and Engineering

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

The engineering/service desert environmental test of the Foxhole Digging Aid (Interim) was conducted by Yuma Proving Ground, Arizona during the period 20 June through 11 August 1966.

The purpose of the test was to determine suitability of the test item for desert use.

Interdependent tests were conducted to determine procedures for handling duds, ruggedness and reliability (air drop), operational characteristics and capabilities. The program was divided into three phases: a period of exposure, air drop and firing. Testing was conducted under summer conditions of extreme temperatures on four representative types of desert terrain.

Five shortcomings were noted which did not seriously impair the operation of the item.

It was concluded that the proposed procedures for handling duds were safe and effective, that the item is suitable for low velocity air drop, that the plastic connection on the cratering charge is suitable for use in the desert summer environment, that personnel can exert sufficient hand force to initiate the explosive, that utilization of two test items is a suitable means for generating an acceptable excavation in desert soil, and that the test item will not contaminate the drop zone after malfunction air drop when the item is rigged in a horizontal position. It was recommended that the procedures developed for handling duds at YPG be incorporated into those proposed by Picatinny Arsenal, that the packages be rigged for air drop with the items in a horizontal attitude, that care be exercised when assembling a cratering charge that has been exposed to extreme heat over an extended period of time, and that the cratering charge be tapered for easier use in the field.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Foxhole Digging Aid						
Ruggedness						
Reliability						
Air Drop Tests						
Dud Handling						
Magazine Storage						
Desert Exposure						

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There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.